Methods in Computational Neuroscience
August 5--September 1, 1990

ONR
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Final Course Report

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Course Directors

Summary

The 1990 version of the course enrolled a total of 22 students including three tenured faculty members for the first time. Overall,we feel that the course went quite well. Overall, student satisfaction was high with the friendly course atmosphere, the MBL environment, dedication of the instructors, and the overall quality of the scientific experience specifically mentioned by many students in their evaluations.

Overall, the course lectures proceeded quite smoothly this year. The student evaluations indicated approximately the same number of students thought the breadth of the course was was just right, who thought that the course should be narrowed in its focus. We take this to mean that we have a good balance. Students were almost universally positive about the quality of the lectures. In planning the lecture series, we invited back the best instructors from the previous years and added several new lecturers this year. We also somewhat changed the schedule reflecting comments made by students in the previous summer. Specifically we somewhat reduced the number of lectures on single cell properties and added several lectures on more abstract modeling techniques. We also enhanced the presentation of small network models. The continuing process of selecting the best lecturers from the previous year, and modifying the lecture schedules no doubt contributes to the year by year improvement in the lecture section of the course.

We continued the tutorials introduced last year in order to cover technical materials in greater detail (GENESIS, Hodgkin-Huxley, numerical techniques, phase-space analysis). These were again generally regarded as a success. We also added two new features to the course largely in response to feedback from previous students. First, on Tuesdays and Thursdays we had informal get togethers between students and faculty who had recently lectured. This was regarded as a success by many students as it provided them with an opportunity to discuss in more detail the lecture subjects. Second, we established small working groups of students interested in similar types of modeling problems. These small groups met throughout the course and shared problems and solutions. This was particularly valuable with respect to the student projects in the student lab.

This summer was the smoothest summer yet as far as the computer laboratory was concerned. Digital Equipment Corporation provided the course with 25 DECstation 5000/200s which provided more than ample computer

capability. Each student was assigned to their own workstation which assured access to computing resources at all times. The range of course projects undertaken in the computer lab this year was also excellent (see Appendix A). In general we found that students were able to advance their models considerably further than in previous years. This partially reflects two years of experience teaching students how to use the GENESIS simulator, and also reflects the fact that a growing number of students have already had some experience with neural simulations (and even GENESIS) before entering the course. This summer we also made available additional GENESIS documentation which helped introduce students to the system. Finally, the computer lab benefited greatly from the addition of Dr. David Beeman as a TA. Dr. Beeman has a long term commitment to educating students in computational techniques having taught computational physics at Harvey Mudd College for many years. He has now become part of the GENESIS development team and will continue to come to MBL in the summer to help with the course.

Student Evaluations and suggestions for improvements:

Based on countless discussions with our students and on the 14 written evaluations , we come to the following conclusions and suggestions for improvements for next year:

1) Several students mentioned that they would like to have an opportunity to prepare for the course before arriving. Accordingly, for 1991, we will send a course outline and suggested readings with each letter of admission.

2) The most frequently mentioned suggested improvement involves the development of additional documentation for GENESIS. Now with grant support from the NSF for documentation preparation we will have this information in the student's hands before the next course.

3) Students thought that there should be more coordination between the lectures and the computer lab. As a result we are developing a series of GENESIS based tutorials that will be specifically linked to the lecture series.

4) Students again requested more of a concentration on methods and less on individual research results. In order to emphasize methods we will continue to stress the importance of a thorough discussion of the methods used by the lecturers in their research. In addition, we have decided this year to invite some faculty to specifically give methodological presentations.

5). In order to provide more time for the lab we will again try to limit lectures to the mornings.

Funding Sources: ONR and NIMH

Appendix A
Training in Methods in Computational Neurscience, 1990
Students and student projects

Aric Agmon (University of California at Irvine)
Firing patterns in neocortical neurons.

Hagai Agmon (Hebrew University)
Action potentials in neuronal dendrites.

Evyatar Av-Ron (Weizmann Institute of Science)
Modeling the cardiac ganglion of the lobster Panulirus interruptus.

Eyal Bartfeld (Rockefeller University)
Simulate neuronal activity pattern in the upper layers of V1 cortex of the cat

Ellen Barton (University of Pennsylvania)
(illness prevented her from undertaking a project)

David Berkowicz (Yale University)
Thalamic Relay Cell Simulation

Neil J Berman (University of Ottawa)
Compartmental model of a basilar pyramidal cell of the electrosensory lateral line lobe (ELL) of weakly electric fish.

Peter Braam (University of Utah)
Modeling phase-locking phenomena in cerebral cortex.

Dennis Bray (MRC)
Simulation of a network of linked enzyme reactions

Anders Dale (University of California at San Diego)
Model several interconnected "typical" cerebral cortical columns.

Trevor Darrell (MIT)
Connectionist modeling

Gyongyi Gaal (University of Pennsylvania)
Modeling a feedforward network (loop) of relatively simple neurons.

Kurt Haas (Albert Einstein College of Medicine)
Hippocampal pyramidal cell model

Dirk Kautz (University of Oregon)
Modeling acoustic motion sensitivity in the midbrain of the barn owl.

Markus Lappe (National Institutes of Health, USA)
Modeling motion processing neurons in are PMLs of the cat visual cortex.

Sean Marrett (Montreal Neurological Institute)
Modeling regional cerebral blood flow and metabolic rates.

Douglas Morton (Case Western Reserve University)
Modeling the central pattern generator (CPG) involved in the feeding behavior of Lymnaea.

Dietmar Rapf (MPI fuer Biologische Kybernetik)
Simulating visual area MT

Walter Schneider (University of Pittsburgh)
Pyramidal cell modeling

Nelson Spruston (Baylor College of Medicine)
Model of a single hippocampal pyramidal neuron

Chris Staub (Brain Research Institute, Zurich Switzerland)
Modeling dendritic voltage transients in response to somatic current injection.

Fan-Gang Zeng (University of Syracuse)
Modeling Hair cells in the vertebrate cochlea

Appendix B.
Training in Methods in Computational Neurscience, 1990
Faculty and Lecturers

James Bower
Division of Biology
California Institute of Technology

Christof Koch
Division of Biology
California Institute of Technology

Paul Adams
Department of Neurobiology
SUNY, Stony Brook

Edward Adelson
Media Laboratory, MIT

Richard Andersen
Dept. of Brain and Cognitive Sciences
MIT

Avis Cohen
Dept. Neurobiology and Behavior
Cornell University

Norberto Grzywacz
MIT

Nancy Kopell
Mathematics Department
Boston University

Rudolfo Llinas
Department of Physiology/Biophysics
NYU Medical Center

Kevan Martin
Dept. Pharmacology, MRC
Oxford, UK

Michael Mascagni
NIH

Kenneth Miller
Dept. Physiology
University of California, San Francisco

John Rinzel
NIH

David Rumelhart
Dept. Psychology
Stanford University

Sylvia Ryckebusch
California Institute of Technology

Terrence Sejnowski
Computational Neurobiology Laboratory
Salk Institute

Allen I. Selverston
Dept. Biology
UCSD

David Van Essen
Division of Biology
California Institute of Technology

Lucia Vaina
Intelligence Systems Laboratory
College of Engineering, Boston University

Matthew Wilson (Lab Instructor)
Division of Biology
California Institute of Technology

Mark Nelson (Lab Instructor)
Division of Biology
California Institute of Technology

John Uhley (Lab Instructor)
Division of Biology
California Institute of Technology

David Beeman (Lab Instructor)
Dept. Electrical and Computer Engineering
University of Colorado

METHODS IN COMPUTATIONAL NEUROSCIENCE
LECTURE SCHEDULE, 1990
August 5 - September 1

Lectures Will be Held in Whitman Auditorium from Aug. 6th through Aug. 19th

Week 1

Mon. Aug. 6

9:15 am — **James Bower**
Aims of the course; methods; requirements
Christof Koch
Introduction to Computational Neuroscience

11:00 am — **Paul Adams**
Voltage- and Agonist-dependent ionic channels

Tues. Aug. 7

9:15 am — **Christof Koch**
Introduction to cable theory; Rall's model of neurons; $d^{3/2}$ law

11:15 am — **Michael Mascagni**
Solving ordinary and partial differential equations: I

Wed. Aug. 8

9:15 am — **Paul Adams**
Hodgkin-Huxley nerve equations

11:00 am — **Michael Mascagni**
Solving ordinary and partial differential equations: II

Thur. Aug. 9

9:15 am — **Christof Koch**
Compartmental models of neurons; simulating α-motoneurons

11:00 am — **Christof Koch**
Calcium dynamics; calcium dependent currents; typical vertebrate neuron: bullfrog sympathetic ganglion cell

Fri. Aug. 10

9:15 am — **Christof Koch**
Dendritic spines; anatomy; passive models; spines and plasticity; spines and active currents

11:00 am — **Christof Koch**
Synaptic input; nonlinear interaction between synaptic inupt; synaptic veto; retinal direction selectivity

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Week 2

Mon. Aug. 13

9:15 am **Rudolfo Llinas**
Bursting and oscillating cells: Purkinje cells and cells in the inferior olive

11:00 am **Christof Koch**
Calcium diffusion; solving cable and diffusion equation simultaneously; NMDA receptors and Hebb's rule

Tues. Aug. 14

9:15 am **John Rinzel**
Phase-space analysis of Hodgkin-Huxley like systems; theory of dynamical systems

11:00 am **Avis Cohen**
Single cell oscillators in invertebrates; central pattern generators

Wed. Aug. 15

9:15 am **Nancy Kopell**
Phase-space analysis of network in lamprey; chain model

11:00 am **Allen Selverston**
The stomatogastric ganglion of the lobster

4:00 pm **Sylvia Ryckebusch**
Designing sensory-motor systems in analog VLSI

Thur. Aug. 16

9:15 am **Dan Alkon**
Molecular, biophysical and behavioral analyses of memory

11:00 am **Allen Selverston**
Using back-propagation to understand CPG's

Fri. Aug. 17

9:15 am **Mark Nelson**
Associative memory; one-layer perceptron and its limitations; Hopfield networks; associative learning in Limax

11:00 am **Christof Koch**
The Hartline-Ratcliff model of the Limulus lateral eye; Recurrent and non-recurrent inhibitory networks

METHODS IN COMPUTATIONAL NEUROSCIENCE
LECTURE SCHEDULE, 1990
August 5 - September 1

Lectures Will be Held in Candle House 104

Week 3

Mon. Aug. 20

9:15 am	**Christof Koch** The correlation model of motion detection; motion detection in fly Musca Domestica. Biophysical implementations
11:00 am	**Edward Adelson** Visual psychophysics: linking motion perception with spatio-temporal/correlation models of motion
4:00 pm	**Mark Nelson** Simulating neuronal networks on parallel computers

Tues. Aug. 21

9:15 am	**James Bower** Introduction to the olfactory system; olfactory bulb and cortex; multi-electrode recording and detailed structural modeling; how to go from one to the other
11:00 am	**Ken Miller** Development and self organization; early models; development in the visual system

Wed. Aug. 22

9:15 am	**Ken Miller** Unsupervised learning; influence of correlated activity and noise in symmetry breaking; detailed simulations of development in cat visual system
11:00 am	**Christof Koch** The gradient model of motion detection; psychophysics and theory of motion detection in primates: network models

Thur. Aug 23

9:15 am	**James Bower** Olfactory processing; 40 Hz oscillations
11:00 am	**Norberto Grzywacz** Computational theories for the recovery of three dimensional structure from motion

Fri. Aug. 24

9:15 am	**Norberto Grzywacz** Testing theories of structure-from-motion with psychophysics and electrophysiology
11:00 am	**Lucia Vania** Clinical approach to studying the algorithms underlying vision; patients showing specefic motion deficits

METHODS IN COMPUTATIONAL NEUROSCIENCE
LECTURE SCHEDULE, 1990
August 27 - September 1
Workshop organized by John Allman, Terrence Sejnowski and Steven Zucker

Lectures Will be Held in Candle House 104

Week 4

Mon. Aug. 27

9:15 am	**David van Essen** The primate visual system
11:00 am	**Richard Andersen** Physiological and neuronal network approaches to study extrastriate cortical areas involved in spatial perception and movement
4:00 pm	**David Rumelhart** The PDP and Connectionist approach towards understanding brain function

Tues. Aug. 28

9:15 am	**Kevan Martin** The basic cell types in mammalian cortex: anatomy, distribution and phsyiology
11:00 am	**David Rumelhart** Modeling cortical computations with back-propagation and other higher-order learning functions; using neural-networks to predict the future
4:00 pm	**James Bower** Oscillations: The Tragedy's Second Part

Wed. Aug. 29

9:15 am	**David van Essen** Detailed models of the visual system: orientation selectivity
11:00 am	**Christof Koch** 40 Hz oscillations in visual system; dynamical systems analysis; 1-D and 2-D simulations

Thur. Aug. 30

9:15 am	**Terrence Sejnowski** Back-propagation as applied to shape-from-shading and the oculo-motor system
11:00 am	**Christof Koch** Modelling phenomena at the interface of neurophysiology and cognitive neuroscience: selective visual attention
4:00 pm	**James Bower** Sensory and motor maps; computational significance of maps; maps and parallel computers

Fri. Aug 31

9:15 am	**Terrence Sejnowski** Learning, Memory and Hebb Synapses: Theories and biophysics
11:00 am	**Kevin Martin** The canonical microcircuit in cortex
2:00 pm	Presentations of Projects to the MBL Community

Methods in Computational Neuroscience

August 4-31, 1991

This four-week course is for 20 advanced graduate students, postdoctoral fellows, and faculty in neurobiology, physics, electrical engineering, computer science, mathematics, or psychology, with an interest in "Computational Neuroscience." The course presents the basic techniques necessary to study single cells and neural networks from a computational point of view, emphasizing their possible function in information processing. The aim is to enable participants to simulate the functional properties of their particular system of study and to appreciate the advantages and pitfalls of this approach to understanding the nervous system. A background in programming (preferably in C or UNIX) is highly desirable.

James M. Bower, Christof Koch, **Directors**, and Kenneth D. Miller, **Associate Director**, Computation and Neural System Program, California Institute of Technology

APPLICATION DEADLINE: **MAY 15, 1991**
Tuition: $1,000 (includes room and board.)
Partial financial aid is available to qualified applicants.

For further information and application forms, contact: **Florence Dwane, Admissions Coordinator, Marine Biological Laboratory, Woods Hole, MA 02543, USA; (508) 548-3705, ext. 216.**

Marine Biological Laboratory

Neural Computation (spring 1991 issue)